



## **Colombia Forestry Development Program**

Contract No. PCE-I-00-98-00015-00 Task Order No. 824

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Forest Planning and Timber Harvesting

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Submitted by:  
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## LIST OF ACRONYMS

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CFDP	Colombia Forestry Development Program
GIS	Geographic Information System
LIDAR	Light Detection and Ranging
dbh	Diameter breast height
cm	Centimeter
ft	Feet
ha	Hectare
km	Kilometer
m <sup>3</sup>	Cubic Meter
m	Meter

## EXECUTIVE SUMMARY

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The purpose of this project is (1) to assist local consultants to define timber harvesting plans for the prefeasibility analysis for the new forestry enterprise in Northeast Antioquia and (2) to guide and assist local consultants and the CFDP team in developing budgets and the schedule of investments in infrastructure and equipment associated with the new forestry enterprise.

In order to develop the operational plan for the first eight years, a prefeasibility study will be developed by Servicios y Consultoría Ltda. for the purpose of estimating equipment requirements for logging, hauling, road construction, and cash flows for three logging scenarios (4 m, 8 m, and 12 m logs). Based upon projected tree size, considerations of topography, and existing infrastructure the harvesting and transport of 8m logs appears to be the most cost effective wood production alternative in the short run. In the longer run, 12 m logs may provide opportunities to reduce logging costs, particularly if good, used logging equipment can be imported.

Cable yarding operations in the Northeast Antioquia region generally use full suspension. This is cost effective and environmentally sound when yarding bundles of short wood, but yarding costs could be reduced by using partial suspension when bringing in 8 m or longer log lengths.

Roads are an important cost component in wood production in Northeast Antioquia. High precipitation, short dry periods, and weak subgrade conditions require aggregate surfacing of roads. Good quality aggregate is scarce and expensive. There are opportunities to reduce road costs through reduced truck wheel loadings and increased road maintenance to protect the road investment.

Training opportunities for local managers and engineers are recommended in order to provide exposure to new technologies and planning methods. External engineering assistance in road design, aggregate testing, geotextile use, variable tire inflation, and economic analysis is recommended to examine options to reduce road costs and provide advice for local conditions.

To provide wood security for the new forest enterprise, substantial new areas of plantation are to be developed. Site productivity, distance to processing center, topography, and availability of road surfacing materials will be important considerations. As part of the process to identify the most profitable locations for establishing new plantations, a transportation plan should be developed for potential areas so that the cost per m<sup>3</sup> for access, logging, and transport can be estimated. Transportation planning will require contour maps of sufficient detail. These maps are not available and should be acquired. New mapping techniques such as LIDAR can be cost effective for providing a digital 3-dimensional map of the terrain for large contiguous areas. Opportunities for LIDAR mapping in Colombia should be examined.

## SECTION I

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### Background & Objective

This Project is being undertaken to support the Colombia Forestry Development Program under USAID's SO2: Promote Economic and Social Alternatives to Illicit Crop Production. Its purpose is to review existing forest inventory, mapping and GIS information and lands available for reforestation and review logging methods and equipment. The specific tasks are to

1. Assist local consultants to define timber harvesting plans for the prefeasibility analysis for the new forestry enterprise. Guide and assist local consultants and the CFDP team in developing budgets and the schedule of investments in infrastructure and equipment associated with the new forestry enterprise.
2. Identify additional work that needs to be performed by external assistance.

## SECTION II

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### Assessment/Analysis

#### A. Field Visit

On January 15, 2005 I had a brief introduction to the goals of the project followed by an overflight of future plantations in the Yarumal and Yolombó areas and a visit to logging operations in the San Antonio area. Accompanying me on this field visit were Vicente Molinos, Alfonso Uribe, Billy Lopez, Mauricio Piedrahita, and Luis Atehortua. On January 17 I reviewed the existing harvesting plans and planning methods of Industrias Forestales Doña María S.A. (Luis Atehortua) and Reforestadora El Guásimo S.A. (William Silva) and the growth and yield estimates of Servicios y Consultoría Ltda.

#### B. Prefeasibility Analysis

In order to develop the operational plan for the first eight years, a prefeasibility study will be developed by Servicios y Consultoría Ltda. for the purpose of estimating equipment requirements for logging, hauling, road construction, and cash flows for three logging scenarios (4 m, 8 m, and 12 m logs). The order of work will be:

1. Identify objective function and constraints (example, Maximize present net value, subject to delivery requirements/Minimize costs, subject to delivery requirements)
2. Identify Stands and Owners
3. Estimate access costs. Roads for 2006+ are already built, but lack surface rock. The list of stands eligible for harvesting is available. Some road projection on maps may be necessary.
4. Identify Prescription(s) for Each Stand (volume per acre, log size)
5. Assign Yarding System based on Logging Scenario
6. Estimate Production and Cost Per m<sup>3</sup>
7. Schedule Prescriptions to meet objective and mill delivery schedule
8. Compile Equipment Requirements for Logging, Hauling, and Construction  
Road Budget, Logging Equipment Budget, Cash Flow
9. Make an office and field review with partner companies

Given the available data from the companies and the work completed to date by Servicios y Consultoría Ltda., the prefeasibility analysis should be completed by February 10, 2005. I will provide assistance and oversight to that effort as necessary.

##### *Logging Scenarios*

1. Use 4 m logs using Tractor-Koller Carriage, Bell Loader, Conventional trucks
2. Use 8 m logs using Bell loader, modified conventional trucks (stakes, w/o bed)  
Assume Koller 501 and modified conventional trucks are available in 2006 if needed to meet sawmill delivery schedule.
3. Use 12 m logs using Koller 501, Hydraulic Loader, Truck tractor with Pole  
Trailer and keep existing yarders working. Assume new equipment is available in 2006.

##### *Roads*

Assume construction of 3.7 m running surface, crowned roads well-maintained. See typical road cross section in Annex A. For the purpose of road cost estimation assume 30 cm of surfacing material compacted to 20-25 cm. Construction costs need to consider available rock sources.

## C. Logging Plan for Existing Stands (Years 1-8)

1. Based on results of prefeasibility analysis and review comments revise the prefeasibility analysis (Begin April 1, 2005)
2. Start preparation of detailed logging plan for selected scenario using the 1:10,000 maps with 10-ft contours the companies already have. Assume that 60,000 m<sup>3</sup> (inside bark) of sawtimber for 2006; 100,000 m<sup>3</sup> sawtimber for 2007 and 120,000 m<sup>3</sup> of sawtimber for 2008 and beyond. According to Luis Atehortua approximately 2700 ha of additional plantation areas of Industrias Forestales Doña María S.A. have access (73 km) but the roads have not yet been surfaced. This access should provide volume for most of the planning period, but this needs to be confirmed. Reforestadora El Guásimo S.A. has less than 6 months of road access constructed ahead.

In order to provide some guidance in estimating yarding costs for the three logging scenarios ( 4m, 8m, and 12 m log lengths) I use the grouped stand statistics described by Servicios y Consultoría Ltda. as representing an “average” of the plantations.

### *“Average” Stand*

The average stand has volume of 340 m<sup>3</sup> per hectare with the maximum log size being 1 m<sup>3</sup>, 1.8 m<sup>3</sup>, and 2.5 m<sup>3</sup> respectively for 4, 8, and 12 m lengths. The average tree size is about 0.3 m<sup>3</sup> with half of the merchantable volume in trees of 12-34 cm dbh and half of the volume in trees 34-58 cm dbh. One cubic meter weighs approximately one metric ton.

### *Four Meter Log Length*

The tractor with Koller carriage and spar tree is capable of yarding 4 m logs. Production is 20-25 m<sup>3</sup> per day. Loading is done with a three-wheel Bell loader with grapple. The yarding cost is about \$US 6.6 per m<sup>3</sup> and the loading cost is about \$US 2.3 per m<sup>3</sup>. Felling, bucking and delimbing is estimated at \$US 2.0 per m<sup>3</sup> giving a stump to truck cost of about \$US 10.9 per m<sup>3</sup> (Table 1).

Existing trucks are two or three axle straight trucks. The two axle trucks have a five meter bed and are loaded to 10 m<sup>3</sup>. The three axle trucks have a 7.5 m bed and are loaded to 20 m<sup>3</sup>. A 0.5 meter overhang is permitted so that a three axle truck could carry two 4 meter lengths.

Current truck transport rates for 15-20 m<sup>3</sup> loads on 3-axle trucks appears to be in the \$US .07-.15 per m<sup>3</sup>-km range with lower standard, slower speed roads costing \$US .25 per m<sup>3</sup>-km for transport.

Road construction costs add about \$US 2-3 per m<sup>3</sup> with \$US 1-2 per m<sup>3</sup> for road maintenance.

### *Eight Meter Log Length*

The tractor with Koller carriage and spar tree is capable of yarding 8 meter logs. Local experience (Luis Atehortua, Industrias Forestales Doña María S.A.) suggests that a 10% production improvement is possible at the 8m log length in clear felling which would yield 22-28 m<sup>3</sup> per day at about \$US 9.8 per m<sup>3</sup> (Table 1)

The trucks are 3 axle, straight trucks with 7.5 m bed. Regulations permit 0.5 meter overhang, so 8 meters can be carried. Truck transport costs would be similar to existing costs. Log positioning (large or small end) would need to recognize weight distribution on the axles as logs would overhang the bed increasing the weight on the rear axle.

Current truck transport rates appear to be in the \$US .07-.15 per m<sup>3</sup>-km range with lower standard, slower speed roads costing \$US .25 per m<sup>3</sup>-km for transport. Road construction costs add about \$US 2-3 per m<sup>3</sup> with \$US 1-2 per m<sup>3</sup> for road maintenance.

### *Twelve Meter Log Length*

Although the tractor with Koller carriage could yard 12 m logs, a larger yarder would be more cost effective. For the purposes of estimating production, a trailer mounted Koller 501 with 10 m tower is used. The Koller 501 has a 0.75 inch skyline and when combined with a slack pulling carriage could average 100 m<sup>3</sup> per day at 500 m span for final harvest in the target stand. Production at shorter distances would be higher. New equipment would require an investment of approximately \$US 140,000 for the yarder, \$US 40,000 for a radio-controlled, slack-pulling carriage, and \$US 240,000 for a 40-50,000 lb class hydraulic log loader on a tracked undercarriage (\$US and US prices). The estimated cost for depreciation, operating, and labor (6 man crew - Colombia labor cost structure) for new equipment would be about \$US 110 per hour for the yarder-loader combination (including interest on investment of 12%). Estimating yarding and loading at about \$US 9 per m<sup>3</sup> plus \$US 1.6 for felling and bucking would put logs on the truck for \$US 10.6 per m<sup>3</sup> (Table 1).

Logs would be loaded on a 350-450 hp tandem-drive log truck tractor with engine brake pulling a stinger-steered log trailer carrying approximately 25-27 m<sup>3</sup>. The investment cost for the log truck with trailer is approximately \$US 130,000 new which yields an hourly cost of depreciation, operation, and labor of about \$US 45 per hour Colombia labor and fuel cost structure. Depending on the number of trips to the new mill, 1-2 trucks per yarder would be needed.

Used yarders, loaders, and log trucks are available in the United States. Hourly operating costs would be similar to the estimates here, but investment costs would be reduced up to 50%. The tradeoff would be more maintenance and parts replacement and somewhat lower equipment availability. Used equipment could possibly reduce stump to truck costs about \$US 2 per m<sup>3</sup> if parts availability and maintenance services were secure.

Road widths greater than 3 m, radii greater than 15 m and road grades up to 12% adverse and 15% favorable are acceptable. Curve widening up to 2 m may be required in deep, small radius curves depending on curve length. Steeper road grades are possible depending upon road surface conditions. The tracked hydraulic loader would need to be transported by lowboy. For some existing roads with limiting alignment, the loader would be required to walk in.

Lower tire pressures for the five axle loading could reduce surfacing and maintenance requirements up to \$US 1 per m<sup>3</sup>.

### *Discussion*

Eight meter log lengths are estimated to provide the minimum stump to truck logging cost if the alternative is to purchase new equipment for 12 m log lengths. If yarding conditions permit and tree size is within the existing yarder capacity, then longer logs could be yarded and bucked at roadside into 4m, 8m and pulpwood lengths for truck transport. This is commonly done elsewhere. If used equipment is purchased for 12 m logs, it is estimated that stump to truck costs could be reduced to \$US 8.6 per m<sup>3</sup>. The difficulty with producing 12 m logs for truck transport to the mill is that it requires a step-change in technology where as going from 4 m to 8 m wood does not. Existing yarding, loading, and trucks can be used for 8 m wood. Unless there are advantages to receiving 12 m logs in terms of woodyard handling and recovery, it appears 8 m wood offers the easiest transition for yarding, but does not take advantage of opportunities to reduce road costs through reduction of tire loads. As production ramps up at the new sawmill or as existing equipment needs to be replaced, introduction of good, used equipment for 12-m logs should be phased in and tested.

**Table 1.** Cost summary for stump to mill and road costs for different log lengths and transportation options.

	Log Lengths				Units
	4 m	8 m	12 m	12 m	
Equipment	Existing	Existing	New Equipment	Used Equipment	
Fell/Buck	2.0	1.8	1.6	1.6	\$US/ m <sup>3</sup>

Yard	6.6	5.9	4.5	4.0	\$US/ m <sup>3</sup>
Load	2.3	2.1	4.5	3.0	\$US/ m <sup>3</sup>
Stump to Truck	10.9	9.8	10.6	8.6	\$US/ m <sup>3</sup>
Truck	Straight Truck	Straight Truck	Truck with Pole Trailer	Truck with Pole Trailer	
Transport Cost	.07 to .15	.07 to .15	.07 to .15	.07-.15	\$US/m <sup>3</sup> -km
Road Construction	2.0 to 3.0	2.0 to 3.0	1.5 to 2.0	1.5 to 2.0	\$US/ m <sup>3</sup>
Road Maintenance	1.0 to 2.0	1.0 to 2.0	1.0 to 1.5	1.0 to 1.5	\$US/ m <sup>3</sup>

Existing Equipment = Tractor with Koller Carriage

New Equipment = Imported New Equipment

Used Equipment = Imported Used Equipment

Truck tractors with pole trailers offer potential road surfacing cost reductions through reduced axle loading. If new plantations are established in areas that will require high road density and/or more expensive road surfacing, the long log option becomes more cost effective. In any case, opportunities to reduce road investments through reduced axle loading should be examined. Road options are discussed later.

## D. Additional Work

Additional work needs to be done to (1) identify new plantation areas, (2) examine opportunities to increase yarding production and reduce costs, (3) examine opportunities to improve road access and reduce road costs.

### D.1 Identification of New Plantation Areas

To identify the best locations for future plantations, the cost per cubic meter for candidate plantations needs to be evaluated along with site productivity. This evaluation should consider distance to potential sawmill sites, land productivity considering species and growth, harvesting and transport costs, and road construction costs. In order to produce an estimate of the cost per cubic meter for candidate new plantations the following two-phase procedure is recommended.

#### Phase I (Begin April 1, 2005)

1. Identify land use and vegetation cover for selected areas.
2. Identify productivity and general management prescription
4. Determine access and harvesting system from terrain analysis. This requires a digital terrain model either developed from photos or LIDAR. Cost considerations for LIDAR are given in Annex B.
5. Identify rock sources and quality and calculate road costs by road segment
6. Calculate logging and transport cost per m<sup>3</sup> for each candidate using results from the Prefeasibility analysis

#### Phase II

Objective: Identify candidate stands to meet objective (such as Maximize net mill value and delivery requirement)

1. Calculate mill value for each candidate (sawtimber, pulp, chips)

2. Identify lands that meet objective (using analytical search technique)
3. Compile revenue, cash flow, equipment requirements, road access schedule
4. Evaluate log merchandizing strategies (sort yard locations) and alternative destinations.
5. Review with partner companies
6. Revise as necessary

## **D.2 Opportunities to Improve Yarding Production**

Longer log lengths will require a change from full suspension to partial suspension to reduce line tensions and permit larger loads. In other parts of the world, full suspension is common across streams for environmental protection of riparian vegetation and water quality, but partial suspension for uphill yarding outside of riparian areas is the accepted norm for efficient production of log lengths. Downhill yarding on very steep slopes may require full suspension for log control, but yarding costs will be higher. The current full suspension of pulpwood bundles would continue. Partial suspension of pulpwood bundles is not recommended due to ground disturbance. Concerns were expressed about increased cable wear due to partial suspension. Experience elsewhere has shown that partial suspension extends the life of the skyline (the most expensive line) by reducing the tension in the skyline and shortens life of the mainline due to the higher tensions required to overcome skidding resistance.

Based upon recent email (January 27, 2005) from Alfonso Uribe, I understand that one of the companies has now tried partial suspension and is having encouraging results.

Consideration should be given to sending one or more company forest engineers responsible for planning to a logging planning workshop in Oregon involving both planning exercises and field visits. This would provide the engineers to look at a variety of equipment and to see the planning methods others are using. Workshops are available through both the Oregon State University Forest Engineering Department and local consultants in the university area.

## **D.3 Opportunities to Reduce Road Costs**

Existing roads are constructed by excavator, graded, allowed to consolidate for up to one year and then 25-30 cm of soft pit run rock is spread and compacted to a depth of 20 cm.

Heavily loaded straight bed trucks are used to transport as many as 20 m<sup>3</sup> of logs on 3 axles as compared to US Pacific Northwest loads of 25-27 m<sup>3</sup> on 5 axles requiring a greater depth of rock aggregate to protect the subgrade. Road maintenance consists of filling in ruts with aggregate by hand. Blading is not done. Road crown is not maintained. After rains, water ponds in local depressions, potentially weakening the subgrade. Trucks use bias ply tires to provide sidewall resistance to puncture from large surface rock.

Potential reductions in surfacing requirements could be realized if tire loads were reduced. If pit run rock were restricted to the sub-base, and a surface layer of finer rock used, grading would be effective for maintaining the road crown. Radial tires could then be used on trucks improving fuel economy and providing the opportunity of using reduced tire inflation pressure to further reduce road surfacing requirements, improve traction, and reduce road rutting and wash boarding (lateral corrugations).

These considerations become more important in areas that will require a higher road density (greater number of meters of road per hectare) and in areas where rock surfacing is expensive.

Consideration should be given to bringing in an engineer with experience in road design, surfacing design, aggregate testing, geotextiles, and variable tire pressure operation to evaluate options to improve access and reduce road costs.

## SECTION III

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### Recommendations & Next Steps

1. Move to 8-meter logs to supply the sawmill during a transition period. Where appropriate, yard longer logs and buck at roadside.
2. Change yarding of longer logs from full suspension to partial suspension to improve production and reduce cost.
3. Increase yarding capacity by introducing good, used equipment and evaluating production and cost for producing 12-m logs.
4. Provide training opportunities for forest engineers in the companies to visit yarding operations in Chile and western US and to attend a cable layout workshop.
5. Provide training opportunities for forest engineers in the companies to visit road construction and maintenance operations to learn about recent developments in road construction and road maintenance techniques.
6. Bring in an engineer with experience in road design, road surfacing design, geotextiles, rock testing, use of variable tire pressure, and economic analysis to examine road surfacing options and provide advice for local conditions.
7. Evaluate the use of radial tires for truck transport. Advantages include lower fuel usage, superior cornering, and ability to achieve higher traction through lower tire pressure (in conjunction with Recommendation 6).
8. Evaluate tradeoffs between lower axle loadings and road construction and maintenance cost savings (in conjunction with Recommendation 6).
9. Evaluate cost and operational considerations to using LIDAR to produce a digital platform for developing planning maps for reforestation and harvest layout.



## ANNEX B

### Benchmarks for Pine Production Cost

The CFDP technical team was interested in benchmarks for wood production costs from other countries that compete in pine sawtimber. I have included some preliminary data from the Southern US, New Zealand, Chile, and South Africa. I will augment this information as additional information arrives.

#### Southern US Pine Sawtimber

Apparent Stump to Mill Logging, Temporary Roads, and Truck Transport is assumed to be the difference between delivered price (what the mill pays) and stumpage price (what the land owner gets). Using an average of the 11-state southeastern US published data

Average Delivered Price is \$51 per ton  
Average Stumpage Price is \$37 per ton  
Apparent Logging Plus Haul is \$14 per ton

If I assume that 1 m<sup>3</sup> green logs = 1 metric ton, then 1 US ton = 0.9 m<sup>3</sup>, so the apparent average logging plus haul cost would be about \$US 15.5 per m<sup>3</sup>.

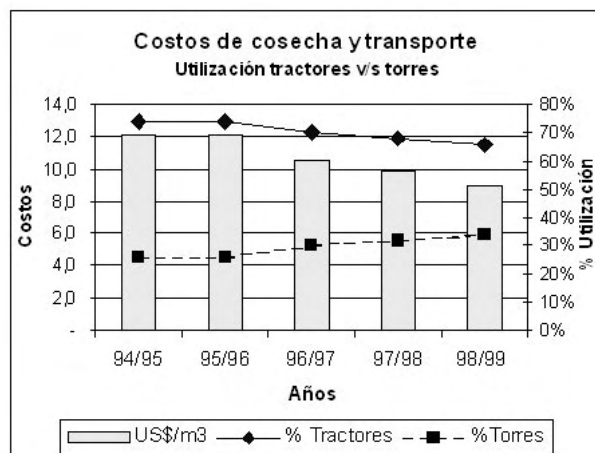
#### New Zealand Radiata Pine

Cable logging, \$US 14 per m<sup>3</sup> on the truck, tree size 3.0 m<sup>3</sup>  
Tractor logging \$US 9.5 per m<sup>3</sup> on the truck  
Truck Transport \$US 6 per m<sup>3</sup> on the truck

Cable logging plus Truck Transport is \$US 20 per m<sup>3</sup>  
Tractor logging plus Truck Transport is \$US 15.5 per m<sup>3</sup>  
Road Construction Cost - Unknown

#### Chile Radiata Pine

Total cost of wood on the truck including roads is about \$12 per m<sup>3</sup>. Mix includes about 30% cable and 70% tractor. Truck transport cost from the landing to the mill is not included. Reductions in total cost have been the result in reducing road density. Current road density is about 33 m per hectare.



Ref: Manuscript on applications of PLANEX in Chile.

South Africa (primarily Pinus Patula)

Cable logging \$US 9.2-10.8 per m<sup>3</sup> on the truck with tree size 1.3 m<sup>3</sup>

Tractor logging \$US 5.8-7.5 per m<sup>3</sup> on the truck

Truck transport \$US 6.7-13.3 per m<sup>3</sup>

Haul costs on highways is about 0.083 \$US per m<sup>3</sup>-km.

Costs cited assume 1 \$US = 6 Rand. The Rand is currently at a multi-year high so the \$US based costs appear 20-30% higher than in recent years.